Turnkey Multi Phase Extraction works.

The submission describes a treatment plant designed and built in the UK and then transported, installed and operated abroad but with remote control from the UK. The client is a major global chemicals company who sought tender submission from the UK, and other continental European countries. It has been in place for several years and needs to function in a wide range of ambient conditions at an active chemicals facility.

Site Description

The site is an active chemicals facility located within a predominantly industrial area but with residential and commercial areas near to the southern boundary. As a result of activities undertaken during previous phases of ownership of the site some areas of the sub surface environment have become contaminated with light molecular weight hydrocarbons; predominantly toluene.

The geology at the site comprises poorly sorted glacial outwash and river terrace deposits containing geology ranging from low permeability silty clays and very high permeability gravels and sands. The water table is located at approximately 20 m bgl but there are 2 significant temporary perched water layers in the contaminated area associated with two expansive low permeability lenses, located at approximately 8m bgl and 12m bgl.

Work undertaken by consultants identified high concentrations of hydrocarbons within the unsaturated zone and the mobility of these contaminants was found to be closely associated with the perched water layers.
the Site has had a simple extraction remediation technique in place which had both reduced contamination and stabilised the contamination, preventing further migration off site, but its effectiveness had been asymptotic and had started to plateau. Accelerated remediation techniques have been requested by the authorities to bring the identified on and off site contamination to agreed levels

Remediation Description

Ecologia were requested to submit design proposals for the installation of an in-situ remediation system to achieve two main functional aims; firstly to ensure that off site migration, within the perched water systems, of contamination from within the facility to external areas was not occurring and secondly to address localised areas of contamination known to be within the unsaturated zone external to the site boundary. One key problem to overcome was the temporary presence of perched water within the unsaturated zone and the design of a system that would be able to capture it when it was present but continue to remediate the unsaturated zone soils continuously. Ecologia focussed upon high vacuum Multi Phase Extraction (MPE) to enable contaminated groundwater and soil vapour to be removed simultaneously. The key design feature was the ability of the technology to respond automatically to the presence of perched water and remove it from the sub surface thereby preventing off site migration.

The MPE system applies a system flow rate of 1000 m^3 air per hour at a vacuum of approximately 500mb (gauge pressure) to the subsurface, removing liquid and vapour via 2” drop tubes (‘slurper pipes’) positioned into 3” wells drilled to either 8m bgl or 12m bgl to intercept the perched water systems. The wells are operated in a cycle to allow repeated alternation of the sub surface thermodynamic system, thereby

maximising the sub surface transport of liquid and vapour and volatilisation of contamination from soil particles.

Extracted liquid and vapour is separated by twin separators to ensure a constant process with vapour being treated with sequential activated carbon filters and the water being treated initially with gravity solids separation and free phase removal and then by biological treatment.

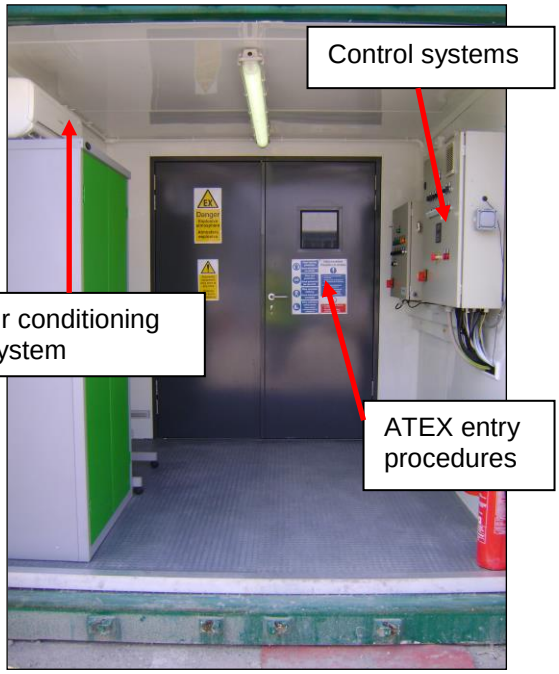
Ecologia undertook the design of the system which includes a total of 28 extraction points, both above and below ground, and manufactured the plant at our workshop in Kent. The equipment was then shipped to to site, then installed and comissioned by staff from our Kent office in stages during 2010 and early 2011.

Above ground extraction point

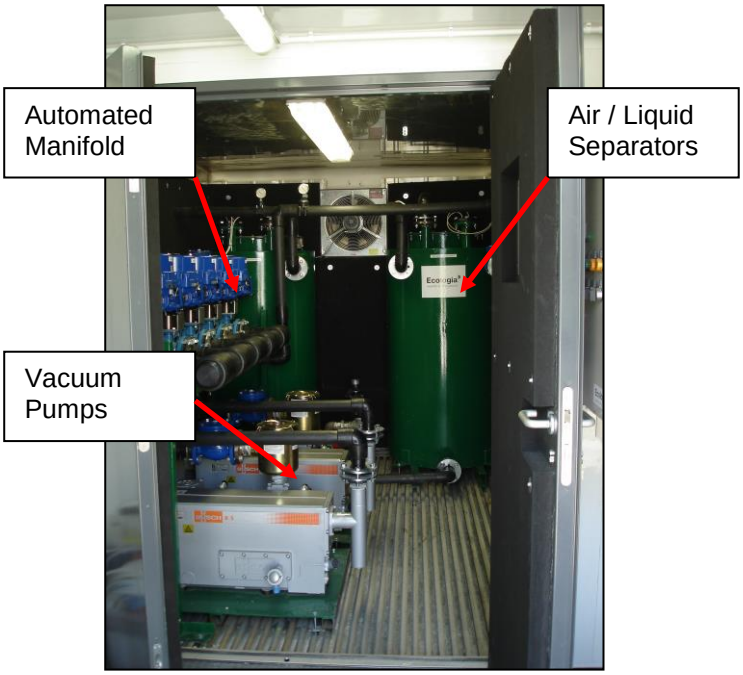
Below Ground extraction point

Represents best, rather than good or average practice

We believe that the remediation system represents best practice because of a variety of aspects including specification, regulation compliance, automation, monitoring and understanding by the client. The equipment was manufactured by Ecologia to a high specification to ensure reliability over a period of years, and to that end high quality components have been sourced. All pipework in the system is electro fusion welded HDPE to eliminate leaks and provide extremely good weathering resistance. This site is located in a part of Europe where summer temperatures will reach as high as 45^{O}C and winter temperatures will drop to -10^{O}C. the systems electrical components are air conditioned to ensure reliability in hot conditions and the water handling components have trace heating to eliminate pipe freezing.



View of the control compartment



View of the plant compartment

The images above show the internal parts of the main system that have been separated with an internal partition to prevent human contact with an ATEX zone. The control compartment is a quiet, air conditioned safe area and a standard entry procedure to the sound-proofed plant compartment is in place with training having being provided to authorised staff on site during commissioning works.

The whole system is completely automated and monitored remotely by our staff in Kent allowing preventative maintenance requirements to be noted in advance of a more serious problem; for example the system will send a daily update including vacuum level and treatment quantities, any variation from normal can be spotted early on and equipment can be checked; thereby preventing a more serious fault or breakdown.

Ecologia's in-house designed and built automated VOC monitoring and datalogging system

One crucial aspect of the monitoring is an automated VOC monitor, designed and manufactured by Ecologia. The system monitors gases from the raw vapour entering the system for mass balance purposes and it also monitors gases between the sequential GAC filters to allow staff to be alerted by SMS text when the carbon filer needs changing. In addition the system also monitors the exhaust stack and is capable of automated shutdown in event of an emissions level breach in excess of the local authorisations.

One key element of the success of the system has been the involvement of client staff; Ecologia have provided training for site staff to use the system and become involved in the project. We believe that this represents best practice because it creates a genuine cross-stakeholder team engaged in the project.

Health and Safety, Environmental Permitting and Stakeholder Acceptance

A fundamental health and safety concern was the operation of an electromechanical system within an active chemical plant that has been designed to treat light molecular weight hydrocarbons. To control the potential explosion risks the system was fully ATEX assessed by our internal trained staff at design stage and then assessed following manufacture by an external consultant prior to being given a CE mark. The ATEX assessment must take into account potential human exposure to a potentially explosive atmosphere as well as correct equipment selection for those zones. Ecologia designed a system that exceeded expectations and created a genuinely safe piece of equipment with correctly rated equipment in ATEX zones and entry control to potentially unsafe parts of the system.

The design process involved the previous site owner and their respective consultant so that their views, concerns and ideas could be taken into account within the remediation strategy and the detailed design of the remediation equipment; several meetings, with detailed discussion, were undertaken to satisfy them that the work was to be undertaken to a high standard that would genuinely remove liability.

The project was run by Ecologia under our local remediation licence which is similar to the UK licensing system and the design was subject to scrutiny by the Local Authority and local Environment Agency prior to manufacture. The system of regulator liaison local to the site means that good stakeholder engagement is an essential part of the process; local to the site the process that is defined by CLR 11 in the UK also includes official meetings, where the local environmental regulator, the local authority, the contractor, consultant and the client are all present. These meetings provide an excellent opportunity to openly discuss

and modify the project before work starts. Our commitment to this process and the confirmed satisfaction of the regulators demonstrates the high level of stakeholder involvement and acceptance with the project.

During the process of project design other stakeholder were also involved including local residents and business owners; these were all met and their concerns taken into account in the design of the works.

Remediation Performance - Reduction of the Pollution Burden

We believe that the performance of the system since its commissioning is very high, both in terms of treatment efficacy and durability. One important aspect of the initial testing during the three week commissioning phase included demonstration and verification of the designed radius of influence (ROI). This was carried out with three types of test; traditional ROI testing using radius of vacuum influence, which showed that the equipment was capable of inducing a vacuum at greater than the designed ROI, secondly gas tracer tests were carried out to demonstrate actual sub-surface mass transfer rather than simply induction of vacuum and finally the influence upon the perched water was monitored with pressure transducers, corrected for induced vacuum and atmospheric changes. This element of the works was vital to demonstrate to stakeholders that the design was correct and gave confidence that the selected technology was appropriate.

Since the commissioning phase in September 2009 and April 2011(2 phases of equipment) the system has been continuously monitored and removes approximately 10,000L of contaminated groundwater per day. The water is treated gravimetrically before final treatment at the site's integral biological waste water treatment plant' giving a genuine reduction to the pollution burden rather than transferring it.

The vapour phase is treated with granular activated carbon (GAC) and the spent carbon is sent for re-generation and re-use, greatly limiting the landfill burden that would be incurred by disposal of spent GAC.

To date the system has removed in excess of 15 tonnes of solvent hydrocarbons from the sub-surface at the site, with steady state removal rates (after initial high level concentrations) of approximately 25 kgs per day.

Cost effectiveness and Durability.

The durability of the remediation system formed an essential aspect of the contract between Ecologia and The client. The stakeholders recognised at an early stage that the durability of the system would be key to the success and minimisation of the programme by limiting equipment downtime. Ecologia's engineering capability coupled with the fact that we design and manufacture our remediation plant mean that we were confident to enter into a contract with a maximum of 12 days per year downtime. This has been achieved and key to that success has been the state of art telemetric monitoring system that allows the system to be checked on a daily basis, or on demand, from the UK where our engineers are based.

As mentioned previously the ability to identify small changes in performance with the remote monitoring system has been extremely useful in predicting when maintenance is required and ensuring continued performance of the system.

It is unrealistic to expect electromechanical equipment to never break down so Ecologia undertook a critical parts analysis at the start of the project to identify key components with a long order period. These items were installed as duty / standby equipment (i.e. two of each), or spares were purchased and kept on site so that in event of a breakdown the equipment could be repaired without waiting for components to be ordered.

There are a number of ways to measure cost-effectiveness and because the project is in-situ a volumetric or areal basis does not necessarily provide an accurate measure of the importance of the project. Other factors ought to be taken into account such as the protection of human health, the protection of natural resources and the removal of corporate liability but are all discarded when cost effectiveness is measured on a volumetric basis. However, we have been able to measure the amount of hydrocarbon that has been removed from the ground with continuous datalogged monitoring, and sampling of the aqueous phase, to arrive at a quantity of 15.3 tonnes of hydrocarbon removed from the sub surface at an overall cost of approximately £830,000.00. This equates to approximately £54 per kilo of hydrocarbon removed by the system. To put this into perspective 1kg of Toluene would equate to contamination of 2.04×10^5 m^3 of air based upon a human health TDI inhalation of $4.9 mg/m^3$, using the water guideline value of 0.05mg/l would equate to 2.0×10^7 litres of groundwater. We believe that the durability, and price, of the system represents very good cost effectiveness and this has been brought about by a combination of a detailed design stage, bringing our wide range of internal skills to bear while working closely with stakeholders, and agreeing a workable contract that suited the project and the client.